A. Cortis, P. F. Dobson and H. H. Liu,
Review of *Understanding the Micro to Macro Behaviour of Rock–Fluid Systems*, in *Journal of Sedimentary Research*.

The book consists of a series of summaries of studies supported by the Natural Environmental Research Council's thematic program of the same name. The objective of this research initiative was to improve understanding and characterization of subsurface fluid flow over a wide range of spatial scales through field investigations, laboratory studies, and computer simulations of these processes.

Following a brief introduction of the volume by Shaw, Keller provides a comprehensive review of the background, objectives and results from selected projects of the NERC's micro to macro program. The discussion of new concepts of scaling, criticality, susceptibility to perturbation, and long-range correlation in subsurface heterogeneity and fluid flow processes is insightful. Keller provides an in-depth discussion of the limitations of currently available approaches in characterizing geology and subsurface property variations and provides recommendations for future developments in this field.

Liu et al. provide an overview of their efforts to apply seismic anisotropy to characterize subsurface fractures. Seismic characterization of fracture permeability has been a longstanding objective for improving reservoir evaluation. This study builds upon previous studies that relate fracture orientation and density from shear-wave splitting by using a dynamic equivalent medium theory that can be used to infer the length scale of fractures from the frequency dependence of anisotropy. The discrimination of the effects of microcracks from those of formation-scale fractures is an important advance in the seismic characterization of reservoir fracture attributes.

Odling et al. provide a comprehensive approach to integrating different parameters (such as fault orientation, density, throw and length distributions) into a stochastic model for estimating hydraulic properties of damage zones in siliciclastic rocks. This model can serve as a useful guide for property determination of similar rock types. Largely because of space limitations, the chapter is too brief in discussing the key elements of the model development, although relevant references are appropriately provided.

Xie et al. present a publicly available computer library for the generation of strongly heterogeneous 2-D random porous media and the computation of flow and transport therein. While this contribution is interesting for the accuracy of the individual simulations and the discussion on the influence of periodic boundary conditions (if such a concept can be applied to real geological media), the comparison with analytical models is limited to the classical work of Dagan (1990). This chapter would be enhanced with a more comprehensive discussion and inclusion of more recent references.

Bloomfield and Barker present a short summary of their work on the modeling of coupling between flow and porosity evolution. This summary does not provide much discussion on this work; more detailed descriptions of the MOPOD code (which relates porosity-growth laws to pore-growth phenomena) can be found in other papers that the authors have published on the subject.

Sellers and Barker provide an interesting discussion of the interpretation of pump tests for fractured systems. Extensive Monte Carlo simulations of water flow (or pressure-head diffusion) were performed for fractured networks represented by Sierpinski carpets. Pressure-head diffusion was modeled with a random-walk method. Based on their simulation results, the authors give an insightful discussion of the limitations of current models for analyzing pump test results for fractal media, demonstrating that diffusive behavior in fractal media is very complex and that a single scaling law with a unique dimension fails to capture the rich behavior of some simulation results. They also call for the development of new models for interpreting pump test data.

Johnston et al. present a study on the classification of non-Gaussian and multi-modal solute breakthrough curves in strongly heterogeneous 2-D porous media into five conceptually distinct classes. Unfortunately, the reference list is outdated and the reader is left with doubts as to the applicability of this classification scheme to real-world geological situations.

Worden et al. use a variety of analytical characterization techniques (XRD, mercury porosimetry, and image analysis of BSEM images) to develop a model linking the mineralogic transformation of smectite to illite with changes in textural fabric and porosity for a suite of North Sea mudstones. A reduction in porosity and an increase in the amount of illite relative to smectite was observed with increasing depth. Changes in fabric anisotropy of the clay minerals observed from backscattered electron microscope images were correlated with the illite/smectite ratio, and the authors conclude that the observed reductions in porosity and increases in clay fabric anisotropy may be due to the mineralogical transformation of smectite to illite rather than from mechanical compaction and grain rotation.

Cassidy et al. present the details of an experimental investigation of flow in fractal-like porous media and comparison with Lattice-Boltzmann flow simulations. The chapter describes an impressive experimental setup for the creation of laboratory-size fractal porous media and the measurement of the fluid field velocity. The declared scope of this work is to provide a reliable benchmark for LB simulations. The authors use the classical Bhatagnar-Gross-Krook (BGK) lattice scheme for their simulations and do not analyze more efficient multiple relaxation time schemes. The authors express their skepticism in the prediction of macroscopic hydraulic parameters (such as hydraulic conductivity) from micro-scale LB simulations. It is not clear whether the self-affine fractal characterization of fractures developed in this study is representative of fractures found in nature.

Brydie et al. evaluate the physical and chemical effects of bacterial biofilm formation on the hydraulic properties of natural porous media over a range of scales. A series of experiments using flow cells and columns was conducted to evaluate the effects of biofilm growth on porosity and hydraulic conductivity at microscopic, mesoscopic, and macroscopic scales. These experiments indicate that the formation of biofilms and the associated precipitation of biogenic minerals cause bioclogging, resulting in significant reductions in hydraulic conductivity. Additional work is needed to determine to what extent the biofilm features observed in their experiments are present in fractured porous media under natural conditions.

The volume concludes with a summary of the NERC research program by Shaw. This overview describes the primary objectives of this program, which can be divided into four general themes: (1) understanding processes affecting rock property and fluid-flow scaling, (2) quantification of critical fluid-flow properties and their spatial variation, (3) development of statistical models and scaling laws to characterize rock heterogeneity and fluid/rock interactions, and (4) understanding the relation between rock property and flow parameter distributions. This is followed by a brief description of each of the 17 research projects supported by the NERC micro to macro program.

The figures of the collected papers are of good quality and the text is accompanied by an index that provides an easy way to locate topics of interest within the different contributions to the volume. The contributions are overviews of work carried out by each research group, and thus the interested reader may be better served by reading the actual journal articles of the authors, where more complete details appear. Additional information is posted on the NERC project

website (http://www.bgs.ac.uk/micromacro/about.html); however, it does not appear that this website has been updated with the most recent publications resulting from this program.